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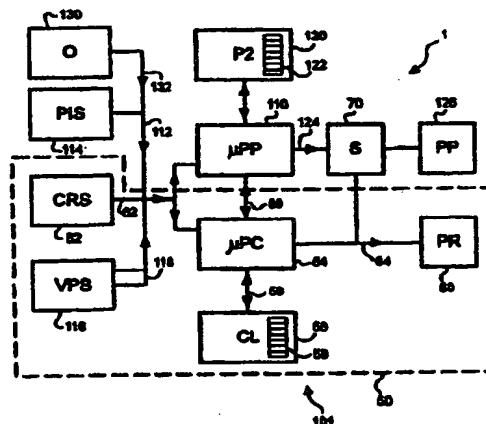
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(54) Title: PEDESTRIAN IMPACT PROTECTION



(57) Abstract: This invention relates to a pedestrian protection method and apparatus for use with a motor vehicle, in particular a motor car. The method comprises the steps of: receiving one or more impact signals (12, 112, 62) from one or more impact sensors (14, 114, 52); receiving one or more vehicle parameter signals (18, 118, 32, 132) from one or more vehicle parameter sensors (16, 116, 30, 130); calculating impact parameters from the received signals (12, 112, 18, 118, 32, 132, 62) using reference data stored in a memory; determining if the impact parameters are indicative of a pedestrian impact; and if so, issuing control instructions (24, 124) for activating an impact protection device (26, 126), characterised in that the control instructions (24, 124) are a function of the calculated impact parameters. This allows the air bag to be activated in accordance with the type of impact that has occurred, thereby affording improved protection to the pedestrian.

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## Pedestrian Impact Protection

This invention relates to a pedestrian protection method and apparatus for use with a motor vehicle, in particular  
5 a motor car.

When a motor vehicle collides with a pedestrian, it is possible to reduce the severity of the injuries suffered by the pedestrian through the use of exterior air bags or  
10 other exterior cushioning mechanisms which can be deployed upon receiving a signal from one or more pedestrian impact sensors mounted towards the front of the vehicle.

It is known from patent document WO 97/18108 to  
15 distinguish between a pedestrian and a non-pedestrian collision. However, this document describes a system in which a trigger signal is sent to a pedestrian cushioning device if a pedestrian collision is sensed, with the result that the cushioning device is deployed  
20 independently of the type of pedestrian collision that has occurred.

It is an object of the present invention to address these  
25 issues.

According to the a first aspect of the present invention, there is provided a pedestrian protection method for a motor vehicle comprising the steps of: receiving one or more impact signals from one or more impact sensors;  
30 receiving one or more vehicle parameter signals from one or more vehicle parameter sensors; characterised in that

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the method further comprises the steps of calculating impact parameters from the received signals using reference data stored in a memory; determining if the impact parameters are indicative of a pedestrian impact; and if so, issuing control instructions for activating an impact protection device, whereby the control instructions are a function of the calculated impact parameters.

The impact parameters may be calculated using an algorithm involving the comparison of values, interpolating between values, changing the memory location of a value or other steps that do not necessarily involve addition or multiplication.

In the present invention the calculated impact parameters are indicative of the type of impact that has occurred. Since the control instructions for activating the impact protection device are a function of these impact parameters, the impact protection device can be activated in accordance with the type of impact that has occurred, thereby affording improved protection to the pedestrian. For example, if the impact protection device is a bonnet mounted air bag, the air bag can be inflated at a higher pressure if a heavy pedestrian is involved, or in the timing of the air bag inflation the vehicle speed can be taken into account.

Preferably, a signal will be received from at least one impact sensor mounted on the front bumper of the vehicle, so as to improve the sensitivity of the sensor to a collision involving a pedestrian. Other impact sensors

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may also be mounted at different locations on the vehicle body to provide further information.

5 The vehicle parameter sensor or sensors will preferably comprise a speed sensor so that a speed signal can be received to indicate the speed at which the vehicle is travelling immediately prior to the collision.

10 Although the vehicle speed may be monitored during the collision solely by the speed sensor, the vehicle parameter sensors will preferably further comprise a crash sensor or other accelerometer sensor, so that information on the change in vehicle speed during the collision can be received. The accelerometer sensor will preferably be  
15 positioned rearward of the vehicle bumper to reduce the chance that it will be damaged during the collision.

The impact signals received will preferably be time dependent. Since certain types of impacts will produce a  
20 distinctive time dependent impact signal, the time dependent signals corresponding to such impacts may be stored in the memory in the form of a look-up table, so that the stored data can be compared to the received time dependent impact signals in order to calculate, by  
25 interpolation or otherwise, impact parameters that are more precisely indicative of the type of impact that has occurred.

30 Preferably, the reference data stored in the memory will be available in the form of a plurality of sets of look-up tables, each set corresponding to a vehicle parameter, and

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- the look-up tables within each set each corresponding to a different values of that parameter. When an impact is detected, and vehicle parameters are received, it will then be possible to compare the time dependent impact
- 5 signal with the appropriate look-up table from each set, in order to calculate parameters that are yet more precisely indicative of the type of impact that has occurred.
- 10 Further look-up tables may be used in determining a functional relationship between the calculated impact parameters and the control instructions for activating the impact protection device so that the impact protection device is activated in an effective manner.
- 15 Possible control instructions may include a time delay instruction such that if the calculated impact parameters are in a predetermined range, the activation of the protection device is delayed in order to activate the
- 20 protection device at the most appropriate moment.
- Other control instructions may include instructions as to the force or speed with which the pedestrian protection device is deployed.
- 25 According to a second aspect of the present invention, there is provided a pedestrian protection apparatus for a motor vehicle comprising: one or more impact sensors; one or more vehicle parameter sensors; hardware having a
- 30 memory containing reference data; and at least one microprocessor connected to the memory and said sensors,

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the microprocessor being capable of receiving input signals from said sensors and accessing the memory, characterised in that the microprocessor is able to calculate impact parameters from the received input  
5 signals using the stored reference data, and if the impact parameters are deemed indicative of a pedestrian impact, to issue control instructions for activating an impact protection device, whereby the control instructions are a function of the calculated impact parameters.

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Preferably, the pedestrian protection apparatus will further comprise a restraints control module, the restraints control module being capable of calculating impact parameters in the event of an impact and assessing  
15 if a pedestrian impact has occurred, and if it is deemed that a pedestrian impact has not occurred, preventing the deployment of the pedestrian protection device. Examples of non pedestrian collisions include collisions between two vehicles, and collisions with lamp posts or walls.

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The invention will now be further described, by way of example, with reference to the accompanying drawings, in which:

25

Figure 1 shows a simplified functional block diagram for a pedestrian protection system according to the invention;

30

Figure 2 is a schematic graphical representation of a time dependent sensor signal Vs for two different pedestrian impacts;

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Figure 3 is a schematic graphical representation of a time delay for pedestrian device deployment as a function of vehicle speed; and

5

Figure 4 shows a functional block diagram showing how the pedestrian protection system can function with a Restrains Control Module.

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Figure 1 is a block diagram illustrating how a simplified pedestrian protection system 1 for a motor vehicle will function. The apparatus has a pedestrian microprocessor ( $\mu$ PP) 10 that can receive pedestrian impact signals 12 from a pedestrian impact sensor (PIS) 14 mounted on or close to the front bumper of the vehicle (not shown). The pedestrian microprocessor 10 also receives a continuously generated signal 18 indicative of the vehicle speed from a vehicle parameter sensor (VPS) 16. A memory location (L) 20 having plurality of look-up tables 22 with reference data can be accessed by the microprocessor 10 to store and retrieve data.

In the event of a collision, the pedestrian impact sensor 14 will produce an impact signal 12 that is time dependent. Hypothetical examples of such signals for two pedestrian impacts are shown in Figure 2, as traces 28,29. The traces 28,29 do not represent real data, but are for illustrative purposes only. A time dependent trace 28,29 will be analysed by the microprocessor 10 and compared with the reference data in the look-up tables 22, taking

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into account the vehicle speed signal produced by the vehicle parameter sensor 16, in order to calculate a plurality of impact parameters indicative of the type of impact that has occurred. If on the basis of this analysis, and the resulting impact parameters, the microprocessor 10 determines that a pedestrian impact has occurred, then the microprocessor will issue control instructions 24 to activate a pedestrian protection device 26.

The control instruction 24 that are issued depend on the calculated impact parameters and determine the manner and timing of the deployment of the pedestrian protection device 26. The impact parameters indicate the type of pedestrian impact that has occurred, so that the pedestrian protection device 26 can be activated in the most appropriate manner.

If the pedestrian protection device 26 is an air bag mounted on the bonnet of the vehicle, it may for example be advantageous for the control instructions 24 to include a time delay command so that once inflated, the air bag does not begin to deflate before being impacted by the pedestrian. The control instructions will also control the speed at which the air bag is deployed (for example by controlling the gas pressure as the air bag is being filled).

These considerations can best be understood with reference to Figure 3, which is a graph of time delay  $t$  before air bag deployment against vehicle speed  $S$ . The time delay  $t$



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is the time interval between the time when the impact is sensed and time when the pedestrian air bag is deployed. The graph is divided into four regions separated by dashed lines at speed thresholds S1, S2 and S3.

5

In the event of a collision, the microprocessor 10 will calculate an impact parameter from the vehicle speed signal 18 and data in look-up tables containing amongst other things the speed thresholds S1-S3. When the vehicle is travelling at a speed below S1, deployment of the air bag is not necessary. Accordingly, the calculated impact parameter will result in a null control instruction being sent to the air bag so that it does not deploy. Similarly, the air bag will not be deployed at speeds greater than S3, since its deployment would be dangerous and of little use.

When the vehicle is travelling at a speed above S1 and below S3, it becomes necessary to deploy the air bag in the event of a pedestrian impact. Since the pedestrian will take a finite time to reach the air bag after the impact signal 12 from the impact sensor 14 has been received by the microprocessor 10, the deployment of the air bag 26 should be delayed by a time delay  $t$ .

25

The look-up tables 22 contain information such as the delay time as a function of vehicle speed, the delay time as a function of the impact sensor signal amplitude and other sensor signal characteristics, so that the microprocessor 10 can access and cross-reference data from these look-up tables 22 in order to calculate impact

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parameters indicative of the type of pedestrian impact deemed to have occurred. The required delay time  $t$  and the speed at which the air is deployed will then be calculated with the use of a further look-up table 22 relating the command instructions to the impact parameters.

As can be seen from trace 38 of Figure 3, the delay time decreases with vehicle speed since when the vehicle is travelling faster, the pedestrian is likely to come into contact with the air bag more quickly.

Above a speed  $S_2$  the required delay time is less than the minimum deployment time of the air bag, and so the air bag will be deployed at a higher rate (by increasing the gas pressure during inflation for example), and a further look-up table 22 containing new delay times will be accessed by the microprocessor 10 when the air bag is deployed at the higher rate.

Trace 39 indicates the expected delay time when the air bag is to be inflated at the higher rate. As with trace 38, the delay time in trace 39 decreases with increasing vehicle speed. For vehicle speeds close to speed  $S_2$ , the delay time is greater when the air bag is to be deployed at the higher rate than when it is deployed at the lower rate.

The graph in Figure 3 is for a single type of impact where the characteristics of the impact are fixed. There will in practice be a whole range of different types of impact

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- having different characteristics depending, for example, on the position of the point or points of impact relative to the vehicle and the pedestrian, as well as the weight and shape of the pedestrian. Thus the memory location 20
- 5 will contain additional look-up tables where the delay time  $t$ , the threshold velocities  $S1-S3$  and the rate of deployment is predetermined as a function of these different impact characteristics.
- 10 To obtain information on the type of impact that has occurred, the microprocessor analyses the time dependence of the impact signal 12. Some types of collisions will produce a distinctive trace indicative of that type of collision. The look-up tables 22 will contain reference
- 15 data on such collisions, enabling the microprocessor 10 to determine what type of collision has occurred by comparing and/or interpolating the measured signal 12 with the reference data.
- 20 The traces 28 and 29 in Figure 2 of hypothetical impact signals may represent impacts with pedestrians of different weight. Both traces 28,29 show the same characteristic structure including a main peak, with trace 28 being shifted to higher signal strength with respect to
- 25 trace 29.

In addition to the vehicle speed, the look-up tables 22 may also comprise data as a function of other vehicle parameters such as the engine speed, the ratio of the

30 engaged gear, the angular position of the steering wheel the extent to which the brakes are being applied and other

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dynamic and/or functional parameters relating to the vehicle. Such parameters may be measured by other sensors (O) 30 that supply other sensor signals 32 to the microprocessor 10.

5

Figure 4 shows how in a preferred embodiment of the invention a pedestrian protection system 101 can include a Restrains Control Module (RCM) 50 of the motor vehicle. In Figure 4, components corresponding to those in Figure 1 use reference numerals incremented by one hundred.

The RCM 50 shown within the dashed line of Figure 4 comprises at least one crash sensor 52 (CRS), a crash microprocessor 54 ( $\mu$ PC), a memory location (CL) for crash look-up table data 58 and passenger restraints 60 (PR). In the event of an impact, whether with a pedestrian or not, the crash sensor 52 sends a crash signal 62 to the crash microprocessor 54 which accesses 59 data in the memory location 56 to determine whether or not a (non pedestrian) crash has occurred, and if so, to activate the passenger restraints 60 with a restraints activation signal 64.

In this embodiment, the RCM 50 is adapted to function with the pedestrian protection system 101. If the crash microprocessor 54 deems that a crash has occurred, the restraints activation signal 64 will be passed to a failsafe feature 70 that prevents the pedestrian protection device 126 from being activated.

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The crash signal 62 from the crash sensor 52 is also

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passed to the pedestrian microprocessor 110. Since the crash sensor 52 is normally an accelerometer mounted towards the front of the vehicle but rearward of the pedestrian impact sensor 114, it will provide additional  
5 information to the pedestrian microprocessor 110. Likewise, to provide additional information to the crash microprocessor 54 (such as the of first contact), the pedestrian impact signal is passed to the crash microprocessor 54 as well as the pedestrian microprocessor  
10 110.

Other vehicle parameters 132 as described above, from sensors designated 130, are passed to both the pedestrian microprocessor 110 and the crash microprocessor 54 and are  
15 used by each microprocessor 54,110 to determine the impact parameters indicative of the type of collision that has occurred.

In the embodiment shown in Figure 4, the crash  
20 microprocessor 54 uses reference data 58 in the memory location 56 to determine the severity of a crash, whilst the pedestrian microprocessor 110 uses data 122 in the memory location 120 to determine if a pedestrian collision has occurred and to classify the severity/type of  
25 pedestrian collision.

In Figure 4 the pedestrian microprocessor 110 and the crash microprocessor 54 communicate via a bus 80, but the functions of these separate microprocessors 54,110 may be  
30 combined within a single processor. Similarly, the memory locations 56 and 120 may also be combined.

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Thus the invention provides an improved method and  
apparatus for the control of passenger protection devices,  
and can conveniently be used alongside or with an existing  
5 passenger restraint system.

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Claims:

1. A pedestrian protection method for a motor vehicle comprising the steps of: receiving one or more impact  
5 signals (12,112,62) from one or more impact sensors (14,114,52); receiving one or more vehicle parameter signals (18,118,32,132) from one or more vehicle parameter sensors (16,116,30,130); characterised in that the method further comprises the steps of calculating impact  
10 parameters from the received signals (12,112,18,118,32,132,62) using reference data stored in a memory; determining if the impact parameters are indicative of a pedestrian impact; and if so, issuing control instructions (24,124) for activating an impact protection device  
15 (26,126), whereby the control instructions (24,124) are a function of the calculated impact parameters.
2. A pedestrian protection method as claimed in Claim 1, wherein an impact signal (12,112,62) is received from at  
20 least one impact sensor (14,114) mounted on the front bumper of the vehicle.
3. A pedestrian protection method as claimed in Claim 1 or Claim 2, wherein a speed signal (18) is received from a  
25 speed sensor to indicate the speed at which the vehicle is travelling immediately prior to the collision.
4. A pedestrian protection method as claimed in any preceding claim, wherein information on the change in  
30 vehicle speed during an impact is received by a crash sensor (30,130).

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5. A pedestrian protection method as claimed in any preceding claim, wherein at least one impact signal received (12,112,18,118,32,132,62) is time dependent.

5

6. A pedestrian protection method as claimed in Claim 5, wherein at least one impact parameter is calculated by comparing a time dependent impact signal with received time dependent impact signals stored in the memory.

10

7. A pedestrian protection method as claimed in claim 6, wherein one or more look-up tables (22, 58) are used in determining a functional relationship between the calculated impact parameters and the control instructions for activating the impact protection device (26,126).

15

8. A pedestrian protection method as claimed in any preceding claim, wherein the control instructions (24,124) include a delay command to delay the activation of the pedestrian protection device if speed signals within a range of speeds are received.

20

9. A pedestrian protection method as claimed in Claim 8, wherein the delay decreases with vehicle speed over a subset range of speeds.

25

10. A pedestrian protection apparatus (1) for a motor vehicle comprising: one or more impact sensors (14,114,52); one or more vehicle parameter sensors (16,116,30,130); hardware having a memory (20,120,26) containing reference data (22,122,58); and at least one

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microprocessor (10,110,54) connected to the memory (20,120,26) and said sensors (14,114,52,16,116,30,130), the microprocessor being capable of receiving input signals from said sensors and accessing the memory, 5 characterised in that the microprocessor is able to calculate impact parameters from the received input signals using the stored reference data, and if the impact parameters are deemed indicative of a pedestrian impact, to issue control instructions for activating an impact 10 protection device (26,126), whereby the control instructions are a function of the calculated impact parameters.

11. A pedestrian protection apparatus as claimed in Claim 15 10 wherein the pedestrian protection apparatus further comprises a restraints control module (50), the restraint control module (50) being capable of calculating impact parameters in the event of an impact and assessing if a pedestrian impact has occurred, and if it is deemed that a 20 pedestrian impact has not occurred, preventing the deployment of the pedestrian protection device (26).

12 A pedestrian protection method substantially as herein described with reference to or as shown in the 25 accompanying drawings.

13 A pedestrian protection apparatus (1) substantially as herein described with reference to or as shown in the accompanying drawings.

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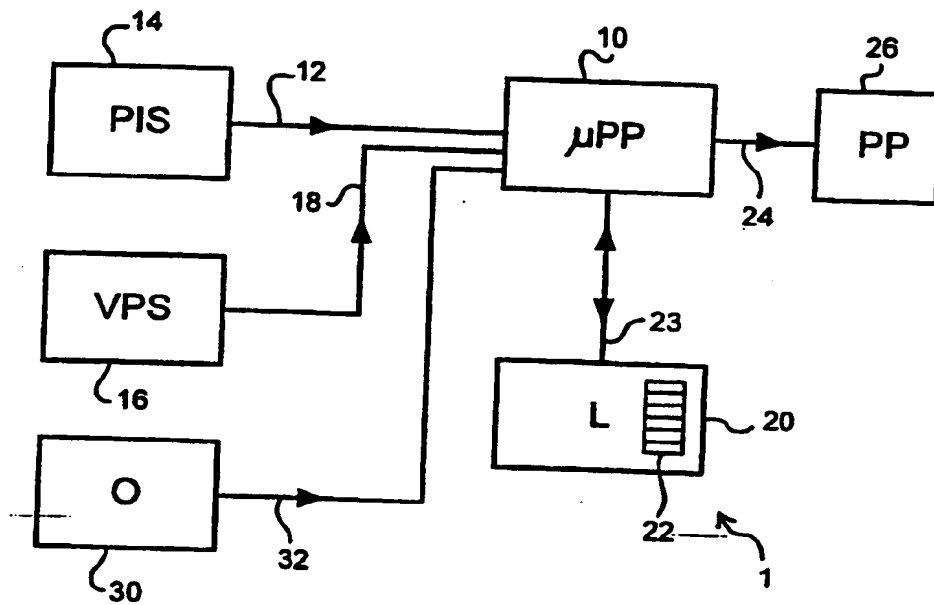


Fig. 1

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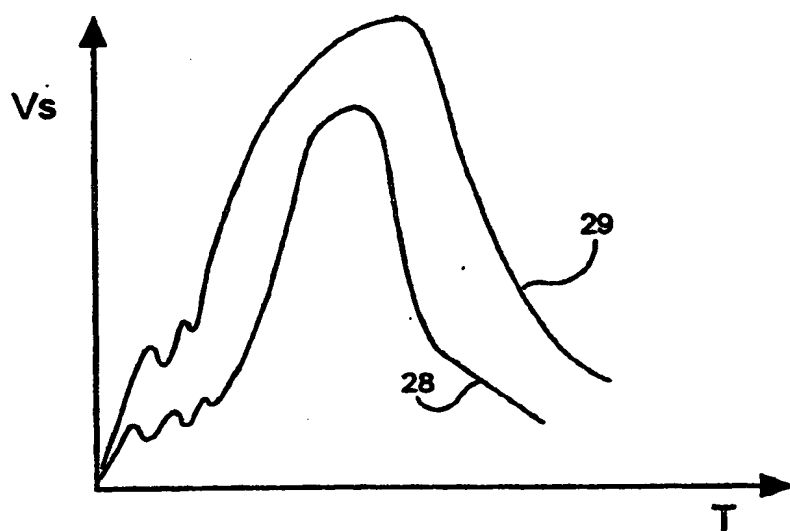


Fig. 2

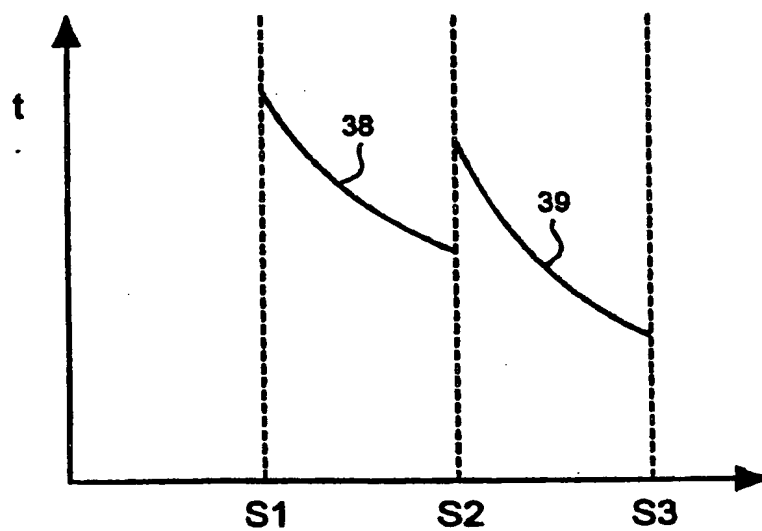


Fig. 3

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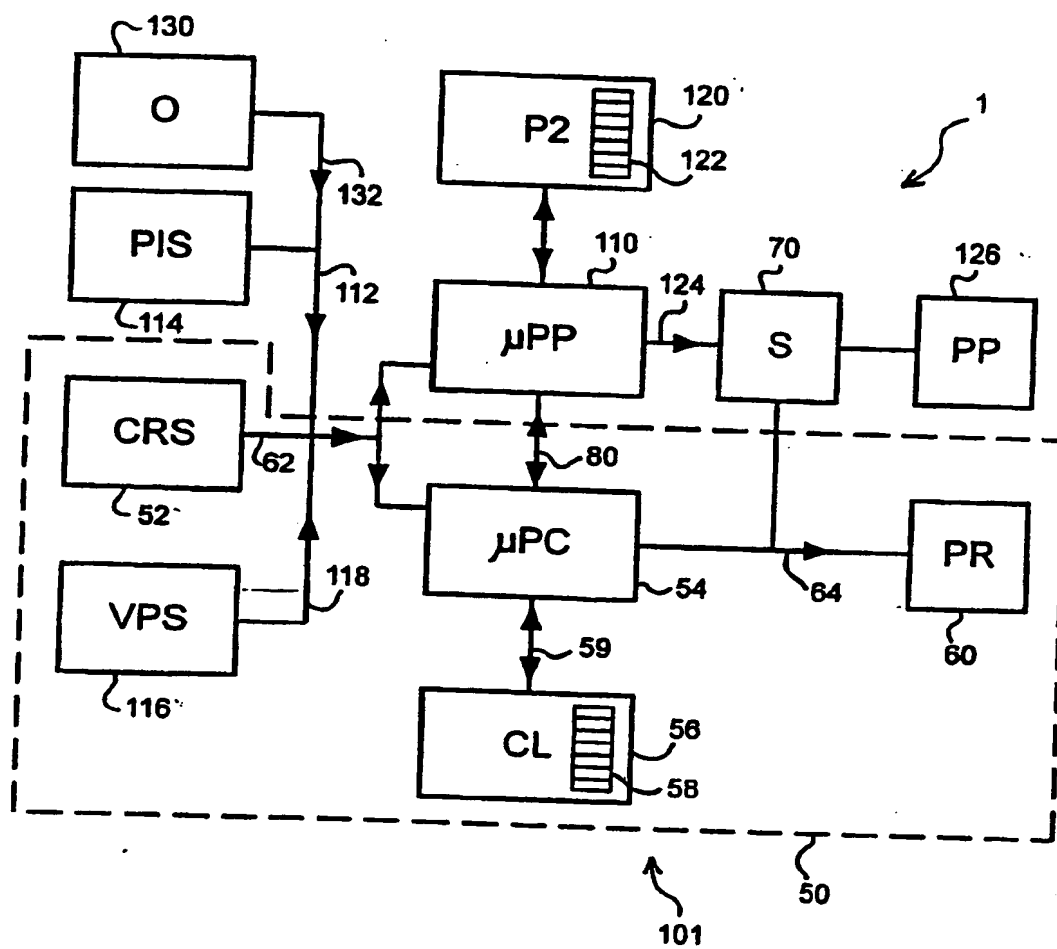


Fig. 4